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Electrocoating method and continuous installation therefor

The present invention relates to a new method of electrocoating electrically conductive three-dimensional substrates in a continuous installation. The present invention also relates to a new continuous installation for implementing the new method of electrocoating electrically conductive three-dimensional substrates.

Methods of immersing and emersing electrically conductive three-dimensional substrates, especially vehicle bodies, in and from the electrocoating bath of a continuous installation are known from patent applications DE 196 41 048 A1, EP 1 170 063 A1, WO 98/15359 A1, WO 01/17691 A1 and European patent EP 0 929 365 B1 and from publications, such as "Status of RoDip Experience: RoDip-3 - New Rotational System for High Capacity Automotive Paint Finishing", DÜRR, Schorbacherstrasse 9, 35510 Butzbach, Federal Republic of Germany; Anonymous, "New technology for high capacity pretreatment and electrocoating of motor vehicle bodies", Surface World 2002, Volume 9, No. 3, page 44, or K. Werner, "Improvement in surface quality by continuous rotational dipping", Besser Lackieren, 2000, Volume 2, No. 13, page 4. In these known methods the vehicle bodies are immersed in the electrocoating

tank with rotation about a horizontal axis perpendicular to the transport direction at an angle > 100° to their original position. On emersion from the electrocoating tank they are then again rotated about the horizontal axis perpendicular to the transport direction into their original position. In total the substrates execute a rotation of 360°.

These known continuous installations are shorter than the known continuous installations in which the vehicle bodies are not rotated during immersion and emersion. In the methods in which the vehicle bodies are rotated during immersion and emersion, moreover, there are fewer sediments, if indeed any at all, on the areas of the vehicles bodies which will become visible later, such as the outside of the roof, of the hood, and of the trunk lid, so that there is no need for labor-intensive work subsequently, such as sanding, polishing or buffing, on the resulting electrocoat. The other side of the coin is that these sediments accumulate to a greater extent in the area of the insides of the roof, of the hood, and of the trunk lid; however, since these areas do not become visible later on, this causes no further disruption to the overall appearance of the finished vehicle.

Rotation of the vehicle bodies does, however, introduce the drawback that the foam that is formed when the vehicle bodies are immersed is caught by the cavities

and the underbody, which can lead to coating defects and considerable detractions from quality in terms of corrosion control, which is especially critical in the area of the underbody and of the cavities. These coating defects may also arise as a result of the hydrogen which is formed during electrolysis and caught.

It is an object of the present invention to find a new method of electrocoating electrically conductive three-dimensional substrates in a continuous installation in the course of which the substrates are rotated on immersion and emersion so that on their outsides of particularly high subsequent visibility there is less sedimentation or none at all and where the foam formed during immersion of the substrates and/or the hydrogen formed during electrolysis in critical areas of the substrates no longer lead/leads to coating defects and considerable detractions from quality in terms of corrosion control.

It was a further object of the present invention to provide a new continuous installation permitting the implementation of a method of electrocoating electrically conductive three-dimensional substrates in a continuous installation in the course of which the substrates are rotated on immersion and emersion so that on their outsides of particularly high subsequent visibility there is less sedimentation or none at all

and where the foam formed during immersion of the substrates and/or the hydrogen formed during electrolysis in critical areas of the substrates no longer lead/leads to coating defects and considerable detractions from quality in terms of corrosion control.

The invention accordingly provides the new method of electrocoating electrically conductive three-dimensional substrates in a continuous installation comprising

- an electrocoating tank containing the electrocoat material,
- an overflow tank containing the electrocoat material,
- at least one circulating pump for drawing off the electrocoat material on the base of the overflow tank,
- at least one circulating pump for drawing off the electrocoat material on the tank base at the end of the electrocoating tank that is opposite the overflow tank,
- at least two flood pipes for returning the electrocoat material drawn off by way of the circulating pumps to the electrocoating tank at its base in such a way that in the electrocoating tank in the longitudinal direction a directed tank flow is produced and maintained,

- the tank flow in the area of the tank base being opposite to the tank flow in the area of the bath surface, and
- at least one conveying device with means of transporting the substrates to the electrocoating tank, rotating and immersing the substrates in the electrocoating tank at one end thereof in the immersing area, transporting the substrates through the electrocoating tank in the longitudinal direction, and rotating and emersing the substrates from the electrocoating tank at its other end in the emersing area,

wherein the substrates

I. are connected as cathode or anode and

II. with the aid of the conveying device or devices

II.1 are supplied over the overflow tank to the immersing area of the electrocoating tank,

II.2 on immersion in the electrocoating tank are rotated about a horizontal axis perpendicular to the transport direction at an angle of > 100° to the original position,

II.3 are passed in the new orientation through the electrocoating tank and coated,

II.4 on emersion from the electrocoating tank are rotated in the emersing area about a horizontal axis perpendicular to the transport direction back into the original position, and

II.5 following emersion are passed on for further processing,

which involves the electrocoat material drawn off by way of the circulating pumps being returned by way of the flood pipes to the base of the electrocoating tank in such a way as to produce and maintain a directed tank flow which flows in the transport direction of the substrates in the area of the tank base and opposite to the transport direction of the substrates in the area of the bath surface.

The new method of electrocoating electrically conductive, three-dimensional substrates in a continuous installation is referred to below as "method of the invention".

The invention also provides the new continuous installation for implementing the method of the invention, comprising

- an electrocoating tank containing the electrocoat material,

- an overflow tank containing the electrocoat material,
- at least one circulating pump for drawing off the electrocoat material on the base of the overflow tank,
- at least one circulating pump for drawing off the electrocoat material on the tank base at the end of the electrocoating tank that is opposite the overflow tank,
- at least two flood pipes for returning the electrocoat material drawn off by way of the circulating pumps to the electrocoating tank at its base in such a way that in the electrocoating tank in the longitudinal direction a directed tank flow is produced,
- the tank flow in the area of the tank base being opposite to the tank flow in the area of the bath surface,
- at least one conveying device with means of transporting the substrates to the electrocoating tank, rotating and immersing the substrates in the electrocoating tank at one end thereof in the immersing area, transporting the substrates through the electrocoating tank in the longitudinal direction, and rotating and emersing the substrates from the electrocoating tank at its other end in the emersing area,
- an immersing area at the end of the electrocoating tank, to which the overflow tank connects, and

- an emersing area at the other end of the electrocoating tank as viewed in the transport direction of the substrates,

wherein the directed tank flow in the area of the bath surface is opposite to the transport direction of the substrates.

The new continuous installation for implementing the method of the invention is referred to below as "installation of the invention".

In the light of the prior art it was surprising and unforeseeable for the skilled worker that the objects on which the present invention was based could be achieved by means of the method of the invention and the installation of the invention.

In particular it was surprising that the substrates coated by means of the method of the invention exhibited very few if any of the sedimentation-induced coating defects on the outsides which were subsequently of high visibility. In addition they no longer exhibited any foam-induced coating defects in critical areas, such as cavities. A particular surprise was that these advantages were achievable with comparative simplicity by modifying existing continuous installations.

Accordingly the substrates coated by means of the method of the invention were clearly superior to the conventionally coated substrates in terms of overall appearance and corrosion control. These particular advantages of the method of the invention appeared with particular advantage in the case of vehicle bodies, especially motor vehicle bodies, since it is particularly in the case of motor vehicles, especially automobiles, that especially stringent requirements are imposed on the appearance of the visible outsides and on corrosion control in the area of the cavities and of the underbody.

A further surprise was that the installations of the invention could be provided with comparative simplicity without great financial, technical, and workplace safety expenditure, by modification of existing continuous installations, so that there was no need for investment in new plant.

The installation of the invention and the method of the invention serve to coat electrically conductive three-dimensional substrates, especially vehicle bodies, radiators, and casings of washing machines, dishwashers, and cookers, with a conventional electrocoat material. The electrocoat material may familiarly be depositable either anodically or cathodically, especially cathodically. This coating method is, as is known, termed electrocoating and the

installation termed an electrocoating installation (cf. Römpp Online, 2002, "Electrocoating installation", "Electrocoat materials", and "Electrocoating", and also the BASF Lackiertechnik handbook, BASF Coatings AG, 2002, Vincentz Verlag, Hannover, pages 497 to 520).

The installation of the invention is a continuous installation, i.e., it is used to coat substrates which are supplied continuously to the installation of the invention and taken off continuously from it again.

The installation of the invention comprises the following essential elements:

- an electrocoating tank containing the electrocoat material,
- an overflow tank containing the electrocoat material,
- at least one, especially one, circulating pump for drawing off the electrocoat material on the base of the overflow tank,
- at least one, especially one, circulating pump for drawing off the electrocoat material on the tank base at the end of the electrocoating tank that is opposite the overflow tank,
- at least two, preferably at least three, very preferably at least four, with particular preference at least five, and in particular at least six flood pipes for returning the

electrocoat material drawn off by way of the circulating pumps to the electrocoating tank at its base in such a way that in the electrocoating tank in the longitudinal direction a directed tank flow is produced,

- the tank flow in the area of the tank base being opposite to the tank flow in the area of the bath surface, i.e., so that the tank flow is made circulating;
- at least one, especially one, conveying device with means of transporting the substrate to the electrocoating tank, rotating and immersing the substrates in the electrocoating tank at one end thereof in the immersing area, transporting the substrates through the electrocoating tank in the longitudinal direction, and rotating and emersing the substrates from the electrocoating tank at its other end in the emersing area, as known for example from patent applications DE 196 41 048 A1, EP 1 170 063 A1, WO 98/15359 A1, WO 01/17691 A1 and European patent EP 0 929 365 B1 and from publications, such as "Status of RoDip Experience: RoDip-3 - New Rotational System for High Capacity Automotive Paint Finishing", DÜRR, Schorbacherstrasse 9, 35510 Butzbach, Federal Republic of Germany; Anonymous, "New technology for high capacity pretreatment and electrocoating of motor vehicle bodies", Surface World 2002, Volume 9, No. 3, page 44, or K. Werner,

"Improvement in surface quality by continuous rotational dipping", Besser Lackieren, 2000, Volume 2, No. 13, page 4, in detail,

- an immersing area at the end of the electrocoating tank, to which the overflow tank connects, and
- an emersing area at the other end of the electrocoating tank as viewed in the transport direction of the substrates.

The installation of the invention may further comprise conventional, additional elements necessary for its operation, such as at least one power supply, electronic, mechanical, and pneumatic measurement and control devices, electric motors, pumps, overflow devices, heat exchangers, devices for supplying electrocoat material, electrocoat material components, and neutralizing agents, ultrafiltration units, filters, anolyte circuits for the cathodically depositable electrocoat, and rinsing zones. These elements are known for example from Römpp Online, 2002, "Electrocoating installation", "Electrocoat materials", and "Electrocoating", and also the BASF Lackiertechnik handbook, BASF Coatings AG, 2002, Vincentz Verlag, Hannover, pages 497 to 520.

For the installation of the invention it is essential that the directed tank flow in the electrocoating tank is made circulating such that it is opposite to the transport direction of the substrates in the area of

the bath surface. A preferred means of accomplishing this is to return the electrocoat material drawn off by way of the circulating pumps to the electrocoating bath at the tank base by way of the flood pipes opposite to the transport direction of the substrates.

The installation of the invention serves to implement the method of the invention.

In the method of the invention the substrates are connected as cathode or anode, in particular as cathode, and with the aid of the conveying device or devices are supplied over the overflow tank to the immersing area of the electrocoating tank, on immersion in the electrocoating tank are rotated about a horizontal axis perpendicular to the transport direction at an angle of > 100°, in particular at an angle of about 180° or 180°, to the original position, transported in the new orientation through the electrocoating tank and coated, on emersion from the electrocoating tank rotated back into the original position about a horizontal axis perpendicular to the transport direction in the emersing area, and following emersion are passed on for further processing.

For the method of the invention it is essential that the electrocoat material drawn off by way of the circulating pumps is returned by way of the flood pipes to the base of the electrocoating tank in such a way as

to produce and maintain a directed tank flow which flows in the transport direction of the substrates in the area of the tank base and opposite the transport direction of the substrates in the area of the bath surface.

Before being returned to the electrocoating tank the electrocoat material drawn off is preferably filtered, in particular by ultrafiltration.

For the method of the invention it is advantageous if the substrates are rotated in transport direction. In the course of such rotation they may be oriented transverse to the axis of rotation or longitudinally to the axis of rotation.

It is also of advantage for the method of the invention if during their transport through the electrocoating tank the substrates are moved, in particular are seesawed in the transport direction or transverse thereto and/or lowered down and up perpendicularly to the transport direction.

The installation and method of the invention are illustrated with reference to Figure 1.

In Figure 1 the reference numerals have the following meanings:

(1) continuous installation,

(1.1) electrocoating tank,

(1.2) overflow tank,

(1.3) circulating pump for drawing off the electrocoat material at the base (1.4) of the overflow tank (1.2),

(1.4) base of the overflow tank (1.2),

(1.5) circulating pump for drawing off the electrocoat material at the tank base (1.6),

(1.6) tank base at the end (1.7) of the electrocoating tank (1.1) opposite the overflow tank (1.2),

(1.7) end of the electrocoating tank (1.1) opposite the overflow tank (1.2),

(1.8) flood pipes,

(1.9) tank flow,

(1.10) bath surface,

(1.11) conveying device,

(1.12) immersing area,

(1.13) emersing area,

(1.14) filter, and

(2) substrates, especially vehicle bodies.

Uncoated vehicle bodies (2) were joined redetachably to the conveying device (1.11) in conventional fashion (cf. for example German patent application DE 196 41 048 A1). The conveying device (1.11) contained conventional means of transporting the vehicle bodies (2) over the overflow tank (1.2) to the electrocoating tank (1.1), means of rotating and immersing the substrates (2) in the electrocoating tank (1.1) in the immersing area (1.12), means of transporting the vehicle bodies (2) through the electrocoating tank (1.1) in the longitudinal direction, and means of rotating and emersing the vehicles bodies (2) at the end of the electrocoating tank (1.1) opposite the overflow tank (1.2), in the emersing area (1.13).

The vehicle bodies (2) were connected as cathodes and with the aid of the conveying means (1.11) were immersed and rotated on immersion about a horizontal axis perpendicular to the transport direction at an angle of 180°, transported through the electrocoating tank (1.1), in which they were coated with a

conventional cathodic electrocoat material, and in coated condition were emersed, in the course of which they were rotated back into the original position about a horizontal axis perpendicular to the transport direction. Following emersion they were passed on by means of the conveying device (1.11) for further processing, in particular for the drying and thermal curing of the cathodically deposited electrocoat film, thereby resulting in the electrocoated vehicle bodies (2).

In the course of electrocoating the electrocoat material was drawn off with a circulating pump (1.3) at the base (1.4) of the overflow tank (1.2) and drawn off with a circulating pump (1.5) at the tank base (1.6) at the end (1.7) of the electrocoating tank (1.1) opposite the overflow tank (1.2), and filtered (1.14). The filtered electrocoat material was returned by way of flood pipes (1.8) to the electrocoating tank (1.1) at its base (1.6) so that in the longitudinal direction a directed tank flow (1.9) was produced and maintained. The tank flow (1.9) in the area of the tank base (1.6) was opposite to the tank flow (1.9) in the area of the bath surface (1.10). The exit apertures of the flood pipes (1.8) were oriented in such a way that the directed tank flow (1.9) flowed in the transport direction of the vehicle bodies (2) in the area of the tank base (1.6) and opposite to the transport direction

of the vehicle bodies (2) in the area of the bath surface (1.10).

The electrocoated vehicle bodies (2) no longer exhibited any paint defects induced by foam and/or hydrogen caught in the underbody area and in the cavities. The corrosion protection effect of the electrocoats was therefore outstanding. In those areas of the vehicle bodies which would later be outwardly visible, such as the outsides of the roof and the outsides of the hoods and trunk lids, there were no paint defects induced by sedimentation, so that prior to overcoating there was no need for any aftertreatment, such as sanding, polishing or buffing.